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Panel Size, Office Visits, and Care Coordination Events: A New Workload Estimation Methodology Based on Patient Longitudinal Event Histories

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Abstract

Background. Panel size, or the number of patients a primary care physician (PCP) and her care team can feasibly manage as part of a practice, remains a vital question in primary care. **Objective.** To Illustrate a new methodology for quantifying two types of workload associated with a panel size: 1) the PCP weekly office visit distribution and 2) the weekly distribution of non-PCP events (subspecialty visits, emergency room visits, hospitalizations) that potentially require non–face-to-face coordination. **Methods.** We assemble granular individual-level histories of events in the health system using the Medical Expenditure Panel Survey from 2011. Using the date on which each event occurred, we create weekly utilization estimates as a function of panel size for the general population and Medicare patients. **Results.** A PCP with a panel of 2,000 adults approximately representative of the US population can expect to have 93.54 office visits on average each week. A simple model quantifying demand–capacity mismatch suggests that a PCP with a weekly capacity of 80 to 90 appointments will struggle to satisfy this office-visit demand in a timely manner. Furthermore, each week the PCP can expect the same panel to have 9.08 visits to the emergency room, 4.69 hospital inpatient events, and 131.29 office-based visits to non–primary care subspecialists; these events contribute to the non–face-to-face coordination workload, increasing the probability of an overburdened workweek. Both PCP office visit and coordination events are highly concentrated in less than 200 individuals ($<10\%$ of the 2,000). **Conclusion.** Patient-level longitudinal event histories can be retrospectively assembled to quantify patterns of face-to-face office visits and coordination workload associated with a primary care panel.

Keywords

care coordination, panel size, patient event histories, primary care workload

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Panel size refers to the number of patients a primary care physician (PCP) and his or her care team manages as part of a practice. The PCP and the care team engage with panel patients in the long term, acting as a first point of contact and helping patients navigate the broader health system. Workload for the PCP and the care team increases with an increase in panel size. Unmanageable panel sizes can lead to extended waiting times, loss of continuity, redundancy, and no-shows. As a recent article points out, a panel size of 2,500, which has long been cited as an estimate, is "neither accurate nor reasonable."[1] With an average panel of 2,300, estimates suggest that a PCP would need to spend over 20 hours a day to care for all acute, chronic, and preventative needs.[2] Physicians attempting to provide all these services in a constrained amount of time are at a much

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higher risk of job burnout, which in turn leads to suboptimal patient care, poor communication, deterioration in the patient–provider relationship, significantly lower patient satisfaction scores, and less satisfaction with physician's work–life balance.[3,4]

Panel size determination has thus far been based on two types of models. The first type of model is deterministic and simply equates the panel size times the number of visits per patient per year to the available annual supply of office-based appointments.[5,6] This approach ignores the randomness inherent in the patient's demand for visits. In contrast, queueing theory considers the interplay between demand and supply rates and mathematically calculates the probability of delays. It demonstrates that planning based on average demand without considering for random demand variation leads to high waiting times and an unbalanced system. Accordingly, the second class of models uses queuing and probability models to set the panel size.[7,8] These models balance the physician's supply of appointments with the uncertainty/randomness in patient requests so that predefined targets such as the probability of obtaining a same-day appointment can be met and delays can be minimized. Such probability models are capable of accounting for various factors such as no-shows case-mix, revisit intervals, and pooling of capacity.[9–13]

However, both the models discussed above only consider demand for office-based visits. Primary care was conceived with the intent of delivering holistic, comprehensive, and coordinated care—long-standing pillars of the profession that have been reemphasized in the concept of the medical home. The PCP and the care team's work, therefore, goes beyond office visits, and an important concern is keeping track of and proactively managing encounters that happen to the physician's patients in the broader health system. The burden of coordination has magnified as organizations have transitioned to ambulatory care: the PCP is now expected to gain content on all patient encounters (whether initiated by PCP or not) and coordinate effectively. However, the time needed to coordinate remains unquantified in panel size calculations.

Patients' encounters in the health care system include hospital inpatient and emergency room (ER0 visits, consultations with specialists, outpatient specialists, home health care, prescribed medications, and diagnostics. Many of these encounters require additional coordination by the PCP and/or care team, such as contacting and communicating over phone and email with patients, family members, and caregivers; conducting home visits or intensive outreach programs for high-risk patients; contacting other clinicians/specialists regarding patient referrals; evaluating diagnostics and tests conducted by the PCP as well as those sent by specialists; and contacting hospitalists and other clinicians after a hospital inpatient stay to obtain discharge summaries. It has been shown that the period following hospital discharge, during which these coordination tasks are numerous, is a particularly vulnerable time for patients.[14] In a perspective piece for the *New England Journal of Medicine*,[15] Dr. Matthew Press—an internist at the Massachusetts General Hospital—points out that "care coordination is not just a value proposition (higher quality, lower costs) but a patient-safety issue. Patients can be harmed when the many moving parts of their care are out of sync." To illustrate, Dr. Press carefully documented his care coordination tasks on behalf of a 70-year-old patient in his panel (Mr. K in excerpt below), after tests revealed a kidney stone and cholangiocarcinoma:

> Over the 80 days between when I informed Mr. K. about the MRI [magnetic resonance imaging] result and when his tumor was resected, 11 other clinicians became involved in his care, and he had 5 procedures and 11 office visits (none of them with me). As the complexity of his care increased, the tasks involved in coordinating it multiplied. . . . In total, I communicated with the other clinicians 40 times (32 emails and 8 phone calls) and with Mr. K or his wife 12 times. At least 1 communication occurred on 26 of the 80 days, and on the busiest day (day 32), 6 communications occurred.

The example above shows that the time spent in coordination is linked to events in the broader health system but is hard to quantify since the time is spread across non–face-to-face activities such as phone calls, emails, and reviewing diagnostic results.

In this article, we describe a new methodology based on patient longitudinal event histories in the health system to descriptively estimate two types of workload

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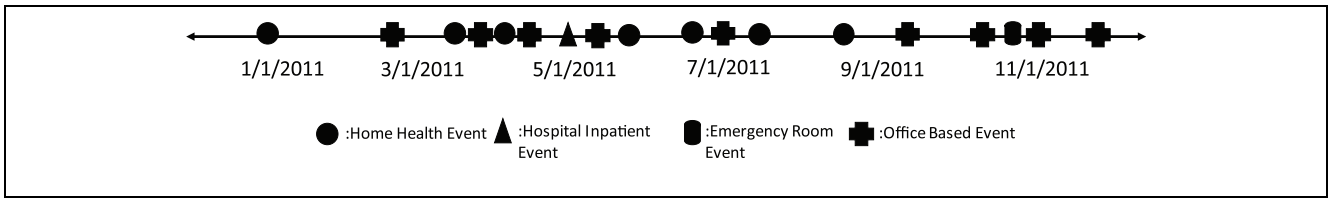

Figure 1. Event timeline for a 69-year-old female in the Medical Expenditure Panel Survey 2011. Each office-based event can be further identified as a primary care physician visit or a subspecialty visit (e.g., cardiologist, ophthalmologist, psychiatrist, etc.)

associated with a panel. Using survey results from a national dataset, we are able to 1) directly infer the weekly PCP office visit count distribution associated with a given panel size and 2) indirectly infer the care coordination workload by estimating the weekly counts of non-PCP events such as subspecialty office visits, outpatient procedures, ER visits, and inpatient hospitalizations generated by panel patients.

Methodology

The Medical Expenditure Panel Survey (MEPS) is a set of large-scale surveys taken annually of families and individuals, their medical providers, their insurance companies, and their employers.[16] The families and individuals are carefully chosen and given a sample weight, so that the survey sufficiently represents the diversity of the United States. Medical encounters for each individual, the type of encounter and the type of provider seen, and the exact date on which the encounter happened are all part of the MEPS data set released each year. By merging various data files, longitudinal information about all health events for each individual can be assembled for a 2-year period. In Figure 1, we show the reconstructed timeline of events in 2011 for a 69-year-old female. This individual has a sample weight of 3,603, which is roughly equivalent to saying that the individual is representative of 3,603 Americans.

Sampling Methodology and Longitudinal Event Histories

We first identify all individuals in MEPS 2011 over 18 years and who respond positively to having an appropriate usual source of primary care (General Practice, Family Medicine, Internal Medicine). From this subset, we randomly sample a smaller panel of $N = 1{,}500$ and 2,000 individuals based on their sample weights. These values of N are based on the approximate range of per physician primary care panel size values suggested in the literature.[1]

We convert the sample weight metric into a probability that the individual will be chosen in our sample of N. Higher sample weight individuals, therefore, have a higher chance of being chosen. Individuals are chosen in a random draw, one at a time, until N unique individuals are selected (to avoid bias, no individual is selected more than once). We only use the sample weight metric to select individuals for the group; once they have been selected, all members are treated equally.

By assuming the N individuals are tied to a single PCP and by assembling their event timelines from January 1, 2011 ($t = 1$), to December 31, 2011 ($t = 365$), we can investigate feasibility of primary care panel sizes by estimating the number of PCP office visits and non-PCP health system events (proxy for care coordination workload) the panel generates for each time period (day or week) of 2011. Figure 2 illustrates this methodology.

All MEPS 2011 health events are classified in one of six ways—Dental, Emergency Room, Home Health, Office Based, Hospital Inpatient, and Outpatient—with each group further subdivided into doctor specialties, location, and care category. We parse through all events of patients in the panel and replace missing date values. Considering only office-based events, 0.42% of members responded with "NOT ASCERTAINED," "DON'T KNOW," or "REFUSED" for the event month question, and 17.54% responded in the same way regarding the event day question. The replacement values were randomly sampled from a range of 1 to 12 months and 1 to 28, 1 to 30, or 1 to 31 days based on the weekly distributions from the known data. We then parse through the office-based events and distinguish between PCP and subspecialty visits. We found that approximately 32% of events were recorded with "NOT ASCERTAINED," "DON'T KNOW," or "REFUSED," regarding the doctor focus. We determined that of the focuses listed, 40% were office-based visits with the member's PCP and 60% were with specialists. Using this ratio, we replace the nonspecific responses appropriately. We then simulate a year from the perspective of the PCP, which enables us to see how many patients requested appointments with the PCP, as well as what other types of care were received by members of the panel on each day.

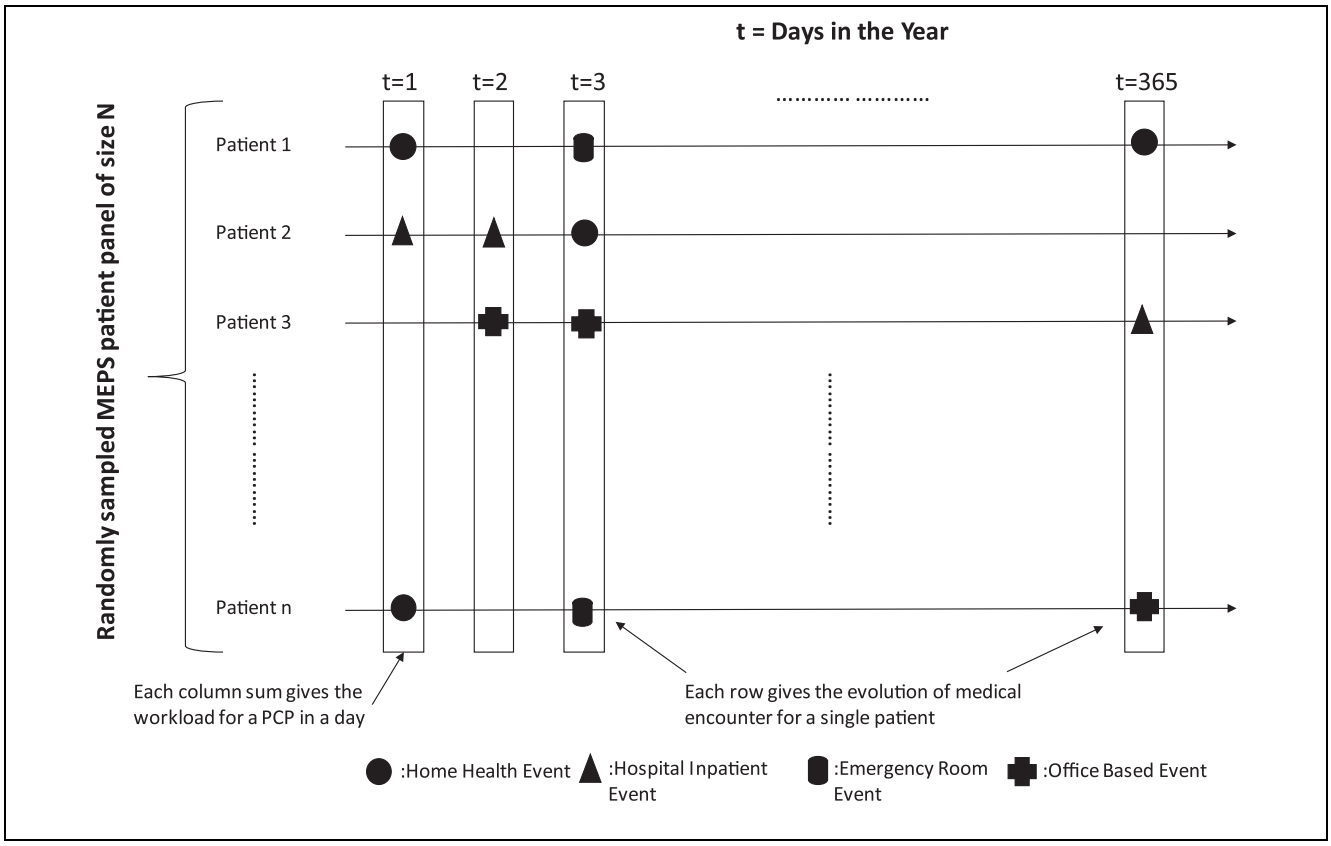

Figure 2. A visual illustration of patient event aggregation, demonstrates how we combine individual's unique timelines in order to create the high level habits of an entire panel.

We apply this panel sampling methodology to two groups:

1. Our General 2011 panel consists of everyone over 18 and who respond positively to having an appropriate usual source of care. This group is approximately representative of the adult national population with a usual source of care.
2. Our Medicare panel consists of everyone over 18 and who respond positively to having an appropriate usual source of care and responds positively to using Medicare.

Additionally, to test the validity of our estimates based on MEPS 2011, we applied the same sampling methodology to MEPS 2013.

Joint Distribution of Weekly Event Counts

In Figure 2, each row can be thought of as the discrete realization of a multi-event stochastic process specific to each patient in the panel. Meanwhile, the event-related workload for the PCP and the care team in any week $w = 1, 2, \ldots, 52$ of 2011 can be viewed as the superposition (i.e., column sum) of the event histories in the week for the N members of the panel. This yields the joint weekly demand distribution for the different event types:

$$\left[PCP_w^N, OB_w^N, OPT_w^N, ER_w^N, INP_w^N, HH_w^N\right]$$
$$\text{for week } w = 1, 2, \ldots, 52$$

In the above vector, PCP_w^N refers to the count of PCP office visits in week w for panel size N; similarly, OB_w^N to the count of non-PCP subspecialty office-based visits; OPT_w^N to the count of outpatient events; ER_w^N to the count of emergency events; INP_w^N to the count of inpatient hospitalizations; and HH_w^N to the count of home health events.

By associating each event type with an estimate of the time it requires for the physician and care team, we can view the PCP and care team's workload in week w as a balance between face-to-face office visits PCP_w^N and other all other health system events $\left[OB_w^N, OPT_w^N, ER_w^N,\right.$

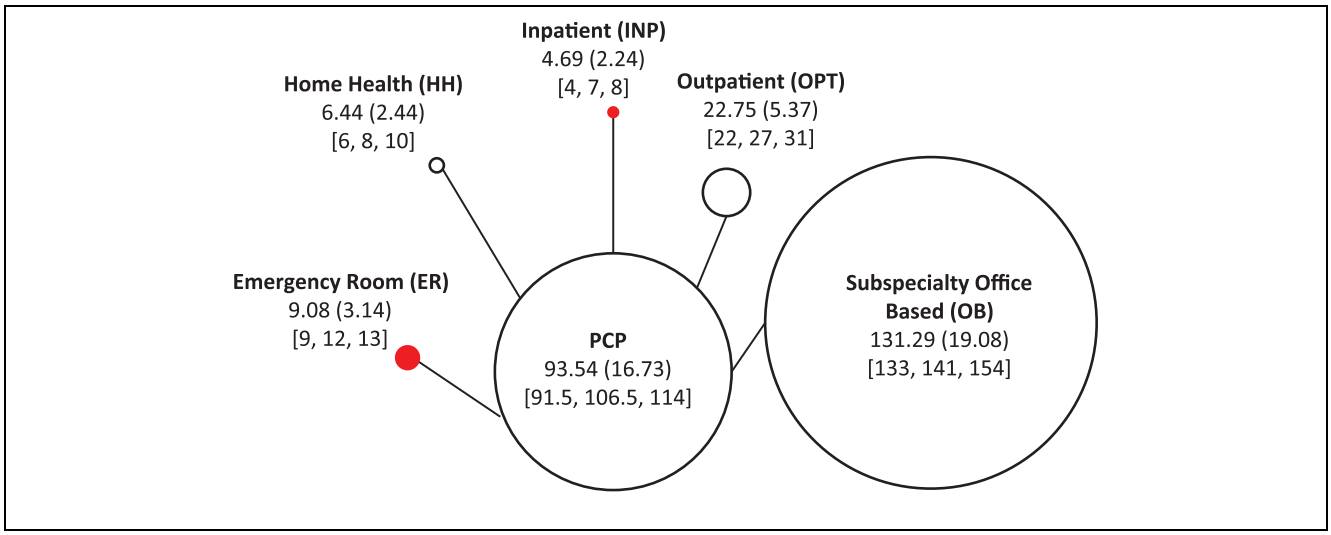

Figure 3. Mean (SD) of observed weekly event counts by event type for the General 2011 Panel, N = 2000. 50th, Second line gives the 50th, 75th, and 90th Percentiles given in brackets.

$INP_w^N, HH_w^N]$ that can potentially trigger care coordination and result in non–face-to-face work.

Demand–Capacity Mismatch for PCP Office Visits

Using the PCP_w^N estimates, which represent the weekly demand for office visits, we can evaluate whether available weekly capacity C for face-to-face office appointments is sufficient for a given panel size N. We create a simple measure called *overflow*, O^N, where

$$O^N = (Number\ of\ weeks\ where\ PCP_w^N > C)/52$$

We evaluate O^N for N = 1,500 and 2,000 and various values of C. Overflow is a naive measure of weekly demand and capacity mismatch and does not consider smoothing the weekly demand though intelligent scheduling (outside the scope of this study). Nevertheless, a high overflow probability indicates that demand in most of the weeks of the year exceeds available capacity with the possibility that 1) panel patients will experience appointment delays or 2) a physician is more likely to be overworked (higher likelihood of burnout).

Results

Weekly Workload Visualization

We start with the General 2011 group, N = 2,000. Panel members have an average age of 52.84 (SD 17.52 years, min 18, and max 85 years). Fifty-eight percent of the members are female and 42% male. The ethnicities break down as follows: White and Hispanic (69%), Black (21%), Asian (8%), American Indian/Alaska Native (1%), Native Hawaiian/Pacific Islander (1%), and Multiple Races Reported (1%). The most common chronic conditions for individuals surveyed in MEPS are essential hypertension, lipid metabolism disorder, diabetes, nontraumatic joint disorders, and spondylosis/intervertebral, disc disorders/other back issues.

We created a network-like visualization of the services that panel members use in each week of 2011. Each event type PCP, ER, Home Health, Hospital Inpatient, Outpatient, and Office Based has associated statistics that are based on the 52 observations for each week in 2011. The size of the PCP circle is fixed for both panels and the other event circles are relative to the PCP circle's size.

Considering the results for panel size of 2,000 (Figure 3), the PCP will see 93.54 patients on average each week, with a standard deviation of 16.73. This translates to seeing 18 to 19 appointments each day of a 5-day week on average, which is a nearly a full workload; the 90th percentile is 114. In addition, somewhere between 4 and 5 patients (average of 4.69) in the PCP's panel will be hospitalized during the week, requiring careful coordination by the PCP—calling the patient or caregiver to schedule the next visit, reviewing the discharge summary, medications, or referring the patient to the right specialists. Furthermore, the PCP and his or her team will have to pay attention to the 9 to 10 patients in the panel (9.08 average) who used the ER.

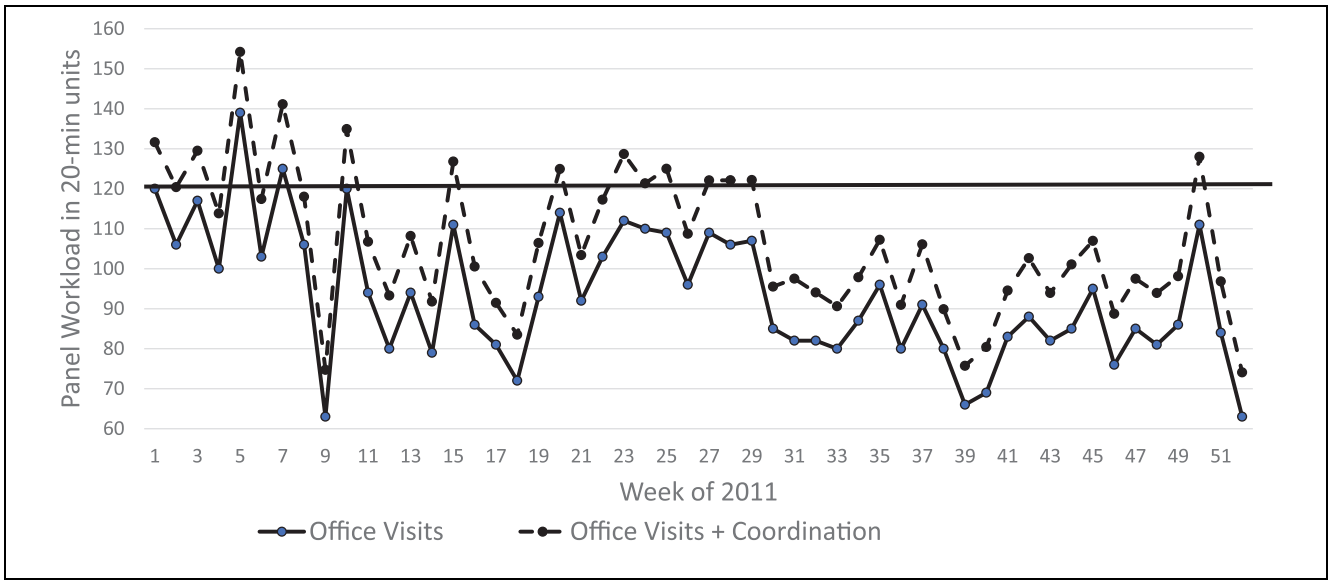

Figure 4. Demand for each week in 2011 expressed in terms of the number of 20-min slots for the General Panel, N = 2000. Since an hour consists of three 20-min slots, a 40-hour workweek contains of 120 such slots, and this is marked with a horizontal line. There are 15 weeks where (office visit + coordination) demand exceeds 40 hours.

We also found that non-PCP subspecialty office visits each week were high: 131.29 on average for a panel size of 2,000. This too takes PCP's coordination time since for at least a portion of these visits, the PCP may have to initiate the referral, exchange emails, or even talk on the phone with specialists, reviewing the patient's history and diagnostic tests. We found that for non-PCP office-based events, patients were most likely to visit a doctor who specializes in gynecology, ophthalmology, orthopedics, or psychiatry. For outpatient-based events, patients were most likely to visit with a doctor who specializes in anesthesiology, immunology, or endocrinology.

Ongoing communication between a PCP and a specialist is required especially in the management of complex or chronic conditions. We found that in the General 2011 panel of 2000, 883 members will not see any non-PCP specialists, 828 will see between 1 and 3 non-PCP specialists, 254 will see between 4 and 6 non-PCP specialists, and 45 will see between 7 and 11 non-PCP specialists. A specialist visit does not necessarily imply that a robust care coordination task is necessary. However, as the number of unique specialists seen by a single patient increases, the likelihood of duplicate or conflicting prescription drugs increases and so does the need for coordination.

Referring to weekly event count averages presented in Figure 3, suppose we assume that the average coordination time for each non-PCP subspecialty office visit takes 1 minute; an outpatient event takes 1.5 minutes; a hospital inpatient event takes 10 minutes; an ER visit 5 minutes; and a home health event 0.5 minutes (since data are not available in the literature, these inputs were based on our personal interactions with physicians). Then, in an average week the physician can expect

$$131.28 \times 1 + 22.75 \times 1.5 + 4.69 \times 10 + 9.08 \times 5 + 6.44 \times 0.5 = 260.92 \text{ minutes (around 4 hours and 20 minutes)}$$

spent in coordination. According to national surveys, each PCP office-based visit takes about 20 minutes on average.[17] Therefore, the 260.92 minutes of coordination is equivalent to 260/20 = 13 office visits each week, and the total average weekly demand, in 20-minute slots, is 93.54 (office visits) + 13 (coordination) = 106.54. Under the same assumptions, Figure 4 shows the office visits demand and office visit plus coordination demand for the General 2011 panel (y-axis) for each of the 52 weeks (x-axis), expressed as number of 20-minute slots needed each week.

The above calculations are only an example illustrating how event count estimates can be potentially translated into time requirements. The specific time and capacity estimates (number of PCP hours per week) will be different from one physician/practice to another. Most subspecialty events may require no coordination at all, while others might require up to 10 minutes exchanging emails with the specialist, sharing information about the patient, with the

Table 1 Overflow Values for Various Values Two Panel Sizes $N = 1{,}500$ and $N = 2{,}000$ and for Various Values of Weekly Office Visit Capacity C[a].

			PCP Office Visits Overflow: O^N	
	Office Visits/Day	Office Visits/Week (C)	Panel Size = 1,500	Panel Size = 2,000
4 days per workweek for office visits	20	80	0.250	0.788
	22	88	0.096	0.519
	24	96	0.038	0.365
3.5 days per workweek for office visits	20	70	0.577	0.923
	22	77	0.365	0.885
	24	84	0.154	0.654

PCP, primary care physician.
[a]Overflow for a panel of size N = (# of weeks in the year that the PCP office visit demand exceeds the available capacity C)/52.

overall average being 1 minute. Similarly, reviewing discharge summaries for an inpatient hospitalization might take only a few minutes for one patient, but for another, it might require additional phone calls and reviews of lab tests adding up to 30 minutes of the physician's time.

Finally, Figure 4 attempts to capture only the PCP office visit and event-related coordination demand but does not account for other non–face-to-face activities such as administrative work, discussions with care team staff, or emails and phone calls with patients that are unrelated to non-PCP events.

Demand–Capacity Mismatch for PCP Office Visits

While time spent in coordination is hard to measure, our methodology does provide a direct estimate of the PCP office visit demand distribution, which can be used to evaluate the feasibility of panel sizes. Table 1 shows the PCP Office Visit Overflow measure O^N for various values of weekly capacity C and two values of panel size, $N = 1{,}500$ and $N = 2{,}000$. The weekly capacity C is arrived at in the following manner. A physician may dedicate a certain number of days of a 5-day workweek for office visits and rest of the time to carry out various non–face-to-face tasks. Furthermore, each physician may have their own limit on the number of office visits they can see each day. Multiplying the number of days of a workweek dedicated to office visits with number of office visits per day (we use typical daily office visit numbers observed in practice), we can derive different values of C as shown in Table 1.

The overflow value flow for $N = 2{,}000$ and C = 88 is 0.519, which means that for more half of the 52 weeks of the year, the PCP Office Visit demand is higher than the weekly capacity of 88, which increases chances of patient delays and physician burnout. Overflow can also be visualized by checking how many weekly observations in the Office Visits line in Figure 4 are above a particular C value on the y axis. A panel size of 1,500 yields lower values of overflow, though the values are still relatively high for $C = 70$ (0.57) and $C = 77$ (0.36).

Validity of Utilization Estimates

How valid are the 2011 weekly count estimates when compared with other years? To answer this question, we applied our sampling methodology to MEPS 2013 and created weekly count estimates for a panel of size 2,000 approximately representative of the national population. We note that individuals surveyed in MEPS 2013 are different from those surveyed in 2011. Despite this, Table 2 reveals that percentiles of weekly counts for all event types in the 2 years are relatively close to each other. A t test comparing the weekly means of the 2 years for each event type revealed no statistically significant difference in samples at the 95% confidence level.

Medicare Panel Results

While a panel size of 2,000 for the general population results in a full workload for a physician, the Medicare panel of the same size will require multiple physicians and nonphysician care team staff to handle the volume of visit and care coordination events (Figure 5). If we use 93 weekly average office visits for the General panel as a reference, the Medicare panel of 2,000 would require at least 1.68 equivalent physicians to cover the 157.02 weekly average PCP office visits. Similarly, the growth in non-PCP events in the health system that may require coordination is considerably higher in Medicare panels for most event types. Inpatient, outpatient, and subspecialty office-based events are over 1.5 times higher

Table 2 Percentiles of Weekly Event Counts by Type of Event for Two Panels of the Size 2,000 Approximately Representative of the National Population, but Sampled From Different Years[a].

	General 2011, $N = 2{,}000$				General 2013, $N = 2{,}000$			
Event Type	**50%**	**75%**	**90%**	**99%**	**50%**	**75%**	**90%**	**99%**
PCP	90	106	114	139	94	98	118	125
Emergency Room	9	11	13	18	9	11	13	18
Home Health	6	8	10	14	7	7	9	14
Inpatient	4	7	8	9	5	6	8	10
Subspecialty Office Based	133	140	154	174	137	147	160	172
Outpatient	22	27	31	35	23	28	30	34

MEPS, Medical Expenditure Panel Survey; PCP, primary care physician.
[a]Individuals surveyed in MEPS 2013 are different from those surveyed in MEPS 2011, yet the percentile estimates are similar.

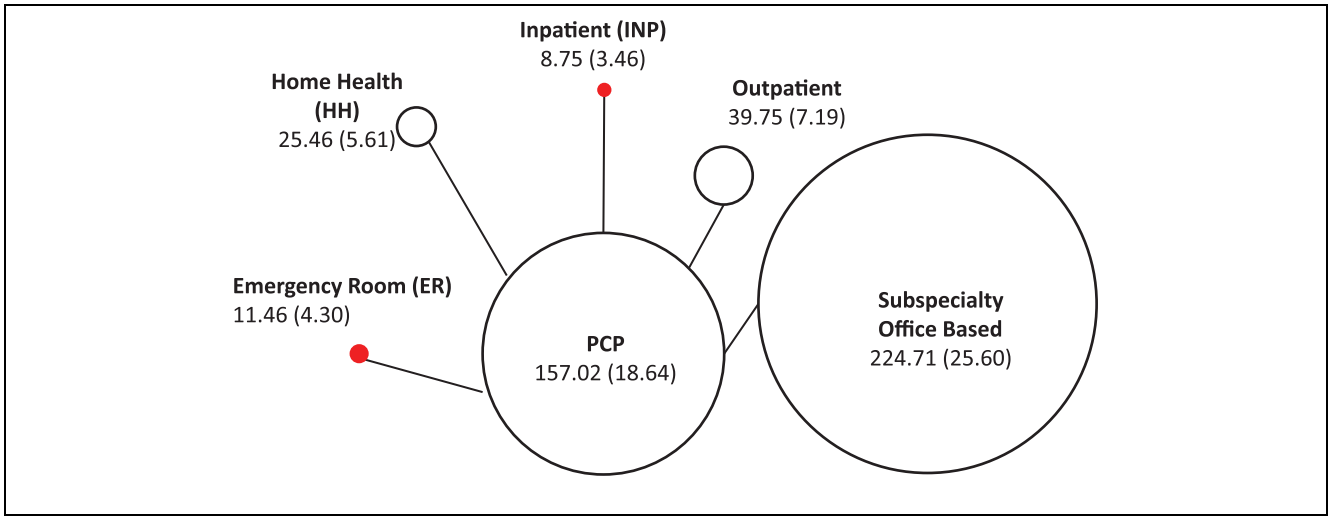

Figure 5. Mean (SD) of weekly counts by event type for the Medicare-only panel (2011) of size N = 2000.

compared with the General panel and home health events for the Medicare panel increase almost fourfold.

Variations in Utilization Trends Within Panel

For each network, we also created an associated table that shows how many panel members visited their PCP X times and had Y ER and Hospital Inpatient events (Tables 3 and 4). Thus, a value in the (3, 4) cell would show how many individuals of the 2,000-member panel visited their PCP 3 times and visited the ER or had a Hospital Inpatient event 4 times over the course of the year. Since PCPs focus on prevention and comprehensive/holistic care and reducing costly adverse events, the relationship between number of times a panel member visited the PCP in a year and the number ER + Inpatient visits that same year is an important metric.

As an example, in the General 2011 panel with $N = 2{,}000$ (Table 3) we see that 581 out of the 2,000 members did not visit the PCP and did not have any ER and inpatient visits for the whole year—these were presumably the healthy individuals in the panel. In total, 687 individuals who claimed to have a usual source of primary care did not visit their doctor for a full year, reducing the effective panel size (in terms of annual PCP office visits) in 2011 to 1,313 individuals. This behavior might explain why only one third of physicians can correctly estimate their panel size.[18]

In the case of the Medicare panel of 2,000 (Table 4), there were only 225 members who did not visit the PCP and did not have any ER and inpatient visits for the whole year. More than half of the General 2011 panel members visited their PCP one or less times per year and have one or less ER/Inpatient events per year, while half

Table 3 Observed Distribution of the General 2011 Panel, $N = 2{,}000$, Based on Number of PCP Visits in a Year (Rows) Versus Number of ER + Inpatient Events in a Year (Columns)[a].

	ER + Inpatient Events →					
PCP Visits ↓	**0**	**1**	**2**	**3**	**4**	**5 +**
0	581	71	19	7	7	2
1	374	47	12	6	1	2
2	215	36	13	4	0	3
3	132	24	10	3	2	2
4	84	19	3	2	2	1
5	45	15	5	1	1	1
6	31	13	4	2	0	1
7	25	6	6	1	0	1
8	26	7	2	0	0	1
9	18	0	2	0	1	1
10	13	4	3	2	0	0
11	9	4	2	0	0	0
12	9	2	2	1	1	0
13	4	3	3	0	0	0
14	3	0	1	0	0	0
15	6	0	1	0	0	0
16	3	0	0	0	0	0
17	3	0	0	0	0	2
18	2	0	0	1	0	0
19	1	0	0	0	0	0
20 +	11	0	2	0	1	1

ER, emergency room; PCP, primary care physician.
[a]For example, the row 3 and column 2 value indicates that there 10 patients in the panel of 2,000 who had exactly 3 PCP visits and exactly 2 ER + Inpatient events in 2011.

Table 4 Observed Distribution of the Medicare-Only 2011 Panel, $N = 2{,}000$, Based on Number of PCP Visits in a Year (Rows) Versus Number of ER + Inpatient Events in a Year (Columns)[a].

	ER + Inpatient Events →					
PCP Visits ↓	**0**	**1**	**2**	**3**	**4**	**5 +**
0	225	25	13	5	3	1
1	264	50	21	5	0	3
2	279	47	24	6	4	2
3	175	33	8	15	3	2
4	129	30	17	3	4	4
5	104	16	13	7	1	3
6	57	20	8	5	1	0
7	52	11	8	5	1	5
8	35	11	3	2	4	1
9	25	7	4	2	0	1
10	35	5	5	0	0	1
11	14	2	3	2	2	0
12	14	2	4	0	1	0
13	12	3	6	1	0	0
14	7	4	3	1	0	0
15	5	2	1	0	0	1
16	4	0	2	0	1	0
17	1	1	1	1	0	0
18	2	1	1	0	0	0
19	0	2	1	1	0	1
20 +	21	1	4	0	2	4

ER, emergency room; PCP, primary care physician.
[a]For example, the row 10 and column 0 value indicates that there were 35 patients in the panel of 2,000 who had exactly 10 PCP visits and no ER + Inpatient events in 2011.

of the Medicare-only panel visits their PCP three or less times per year and have three or less ER/Inpatient events.

In the General 2011 panel, there are a nontrivial number of members who are high utilizers of the PCP, the ER, or both. There are 9 members who had 4 or more ED + Inpatient visits but no PCP visits; and there are 11 members who have 20 + PCP visits and 0 ED + Inpatient events. It is fair to hypothesize that these are the members who require the most face-to-face time and/or non–face-to-face coordination, and also incur the greatest costs in the health system.

Discussion

Our study has two purposes. First, by using a national data set, our findings create utilization benchmarks for the general population and the Medicare population from a primary care panel size perspective. As a recent article points out,[1] there is a shortage of rigorous and data-driven national benchmarks based on patient-driven demand regarding the panel size question.

Second, our methodology demonstrates that patient-level event histories in the health system, to the extent that such data are available, can be retrospectively assembled to quantify granular (daily or weekly) utilization levels that have workload implications. Previous approaches to set panel size use deterministic and probabilistic approaches that aggregate patient demands into total office visits or demand rates. In contrast, we propose a data-driven methodology that considers a comprehensive health system view of patient-centered demand—a view that goes beyond PCP office visits and arguably is more in line with the holistic approach of primary care.

Panel size values reported in the literature range widely, from 1,200 to 1,900.[1] As our General and Medicare 2011 results confirm, there is no one size fits all answer to the question. Each physician or care team

is likely to have a different size depending on a variety of factors such as case mix, practice style, and available capacity. However, the basics of queueing theory state that the capacity must be strictly higher than the average demand to ensure that queues (delays in access) do not spiral out of control. Accordingly, for panels of sizes 1,500 and 2,000 that are approximately representative of the national population, our findings suggest that the number of available weekly appointments must be strictly higher than 72.83 and 93.54, respectively. The more the weekly capacity exceeds these averages, the better a practice's ability to provide timely access to office visits to panel patients.

The methodology used in this study could be used to balance the PCP office visit workload with non–face-to-face coordination work and in particular to set up a care team to assist the physician in these coordination activities. While we used only event types and dates for each patient in our methodology, practices could enhance patient timelines by adding specifics from the electronic health record such as the dates of laboratory tests, phone calls, emails, medication changes, and so on, for each patient. This would allow a more precise breakdown of care coordination tasks for each day and week. Our results suggest that both office visits and coordination work are heavily concentrated in a few individuals. For example, there were 11 individuals in General 2011 panel who had more than 20 PCP visits in 2011, and there were 45 individuals who saw between 7 and 11 unique non-PCP subspecialists. This way of classifying patients identifies individuals who need continued coordination in the upcoming year, and can assist organizations in assessing the need to hire a nurse who specializes in case management of a smaller subpanel of complex patients, or to consider alternative care team models for a broader subpopulation of these complex patients.

Unlike face-to-face office appointments for which approximate quantifications are possible, care coordination is spread across phone, email, chart reviews, conversations, and huddles between physicians and their care team. This explains why studies have focused on a combination of surveys, time studies, and evidence from electronic health records to infer time spent in non–face-to-face coordination. Currently, non–face-to-face tasks have been reported in the literature yet the link between these tasks and patient care needs in the broader health system is not understood. A detailed time study of physician tasks revealed that for every hour of face-to-face time with patients 2 hours are spent on non–face-to-face activities.[19] While further details are not available, many electronic health record activities can be viewed as coordination work linked to events in the broader health system. Pham et al.[20] found through surveying that each physician corresponds with 229 other physicians working in 117 different practices, or 99 physicians and 53 practices for every 100 Medicare panel members.

In contrast to these studies, we use a nationally representative longitudinal survey to quantify office visit and coordination workload associated with a panel size. Our study, however, has limitations. Event histories used in our model are based on patient surveys that had missing data. Furthermore, the event sequences and counts we use reflect only observed data points; we do not account for the factors such as patient preferences, a practice's scheduling rules, the financing system, and organizational structure. Such bias is mitigated somewhat by our sampling of individual histories from across the country. Our weekly event distributions are not tied to precise time estimates since such data are not available in MEPS. Finally, our workload estimates consider only office visits and event-related coordination and leave out other non–face-to-face tasks. These limitations can be overcome in future work by adequate sensitivity analyses and availability of more accurate and granular electronic health record data.

In summary, we have demonstrated that current panel size estimation techniques may be missing some key work factors such as care coordination. Without quantifying the demand–supply mismatch, physicians and care teams risk exceeding capacity limits, affecting patient access, and increasing the chance of burnout. The implementation of "pressure relief" solutions that shift a patient's care elsewhere can add to the complexity and result in a higher coordination burden.

In future work, we would like to conduct a similar analysis with a more intelligent scheduling method than the one we have presented. A model that attempts to smooth high demand and low demand days by moving nonurgent requests with greater scheduling flexibility would create more balanced physician/care team calendars and lower overflows. Additionally, we would like to expand our current care coordination time estimates into more concrete figures by compiling time-study data. Another avenue for future research is to identify common patterns of visit and nonvisit care by different diagnoses groups and comorbidities for predictive modeling, and assigning care teams to high-risk patients with multiple chronic conditions.

References

1. Raffoul M, Moore M. A primary care panel size of 2500 is neither accurate nor reasonable. *J Am Board Fam Med.* 2016;29(4):496–9.

2. Yarnall K, Østbye T, Krause KM, Pollak KI, Gradison M, Michener JL. Family physicians as team leaders: "time" to share the care. *Prev Chronic Dis*. 2009;6(2):A59.
3. O'Malley AS, Cunningham PJ. Patient experiences with coordination of care: the benefit of continuity and primary care physician as referral source. *J Gen Intern Med*. 2008;24(2):170–7.
4. Anagnostopoulos F, Liolios E, Persefonis G, Slater J, Kafetsios K, Niakas D. Physician burnout and patient satisfaction with consultation in primary health care settings: evidence of relationships from a one-with-many design. *J Clin Psychol Med Settings*. 2012;19:401–10.
5. Murray M, Berwick DM. Advanced access: reducing waiting and delays in primary care. *JAMA*. 2003;289(8): 1035–40.
6. Murray M, Davies M, Boushon B. Panel size: how many patients can one doctor manage? *Fam Pract Manag*. 2007;14(4):44–51.
7. Green LV, Savin S, Murray M. Providing timely access to care: what is the tight patient panel size? *Jt Comm J Qual Patient Saf*. 2012;33(4):211–8.
8. Green LV, Savin S. Reducing delays for medical appointments: a queuing approach. *Oper Res*. 2008;56(6):1526–38.
9. Ozen A, Balasubramanian H. The impact of case mix on timely success to appointments in a primary care group practice. *Health Care Manag Sci*. 2013;16(2):101–18.
10. Zacharias C, Armony M. Joint panel sizing and appointment scheduling in outpatient care. *Manag Sci*. 2016;63: 3978–97.
11. Liu N, Ziya S. Panel size and overbooking decisions for appointment-based services under patient no-shows. *Prod Oper Manag*. 2014;23(12):2209–23.
12. Green LV, Savin S, Lu Y. Primary care physician shortages could be eliminated through use of teams, nonphysicians, and electronic communication. *Health Aff (Millwood)*. 2013;32(1):11–9.
13. Bavafa H, Savin S, Terwiesch C. Managing office revisit intervals and patient panel sizes in primary care. *SSRN Electronic J*. 2013. doi:10.2139/ssrn.2363685.
14. Kripalani S, Jackson AT, Schnipper JL, Coleman EA. Promoting effective transitions of care at hospital discharge: a review of key issues for hospitalists. *J Hosp Med*. 2007;2(5): 314–23.
15. Press MJ. Instant replay—a quarterback's view of care coordination. *N Engl J Med*. 2014;371:489–91.
16. Agency for Healthcare Research and Quality. *Medical Expenditure Panel Survey*. Rockville (MD): Agency for Healthcare Research and Quality; 2011.
17. Chen LM, Farwell WR, Jha AK. Primary care visit duration and quality: does good care take longer? *Arch Intern Med*. 2009;169(20):1866–72.
18. Peterson LE, Cochrane A, Bazemore A, Baxley E, Phillips RL Jr. Only one third of family physicians can estimate their patient panel size. *J Am Board Fam Med*. 2015;28(2): 173–4.
19. Sinsky C, Colligan L, Li L, et al. Allocation of physician time in ambulatory practice: a time and motion study in 4 specialties on allocation of physician time in ambulatory practice. *Ann Intern Med*. 2016;165(11):753–60.
20. Pham HH, O'Malley AS, Bach PB, Saiontz-Martinez C, Schrag D. Primary care physicians' links to other physicians through Medicare patients: the scope of care coordination. *Ann Intern Med*. 2009;150(4):236–42.